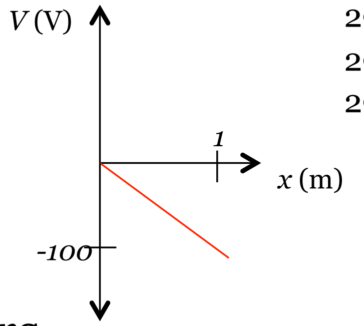
Announcements

- Homework for tomorrow…

  Ch. 29: CQ 8, Probs. 14, 18, & 38

  CQ1:



  29.2: ΔV = 5,000 V

  29.4: ΔV = -550 V

  29.35: see the back of the book

- Office hours…

  MW 10-11 am

  TR 9-10 am

  F 12-1 pm

- Tutorial Learning Center (TLC) hours:

  MTWR 8-6 pm

  F 8-11 am, 2-5 pm

  Su 1-5 pm

Chapter 29

Potential & Field

(*A Conductor in Electrostatic Equilibrium & Capacitance and Capacitors*)

Review…

- *Electric potential difference* from the *Electric field*…

$$\boxed{\Delta V = -\int_i^f \vec{E} \cdot d\vec{s}}$$

  - ΔV = *negative* of the *area* under the E vs. s curve between i & f

- *Electric field* from *potential difference*..

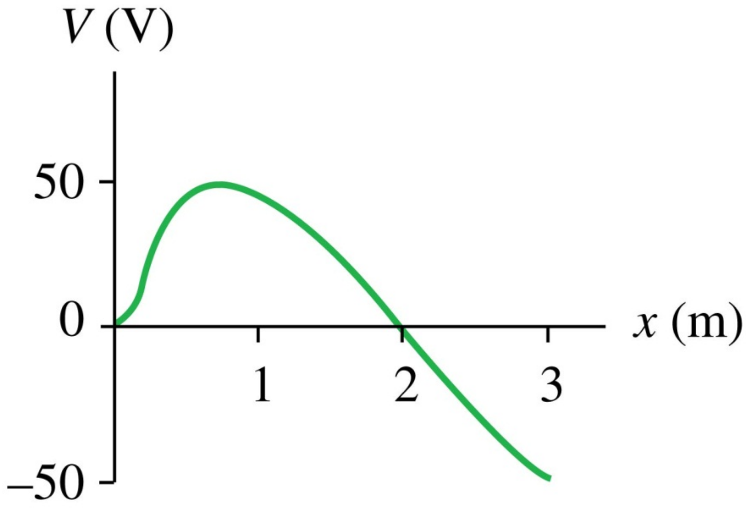
$$\boxed{E_s = -\frac{dV}{ds}}$$

component of E-field in the s direction!

  - E_s = *negative* of the *slope* of the V vs. s curve

Quiz Question 1

An electron is released from rest at x = 2 m in the potential shown. What does the electron do right after being released?

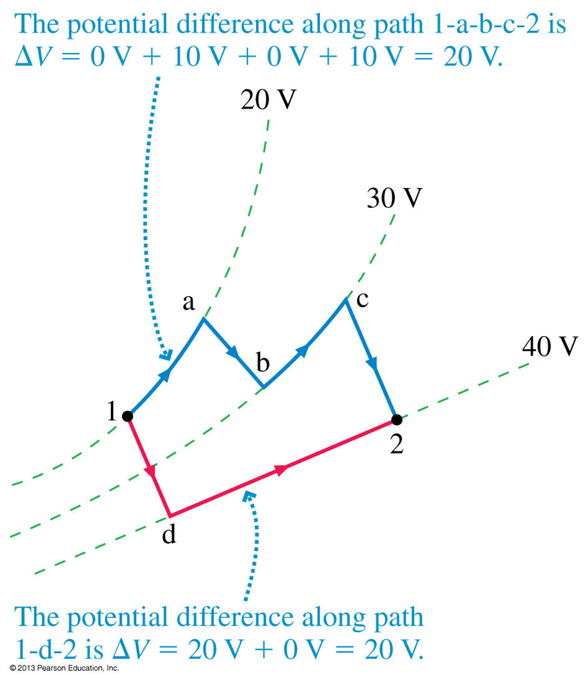


1. Stay at x = 2 m.
2. Move to the right at steady speed.
3. Move to the right with increasing speed.
4. Move to the left at steady speed.
5. Move to the left with increasing speed.

Kirchoff's Loop Rule…

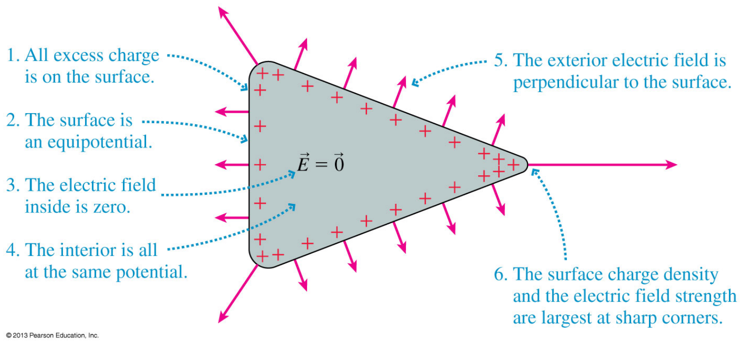
The *sum* of all the *potential differences* encountered while moving around a *closed path* is *zero*.

$$\Delta V_{loop} = \sum_i (\Delta V)_i = 0$$



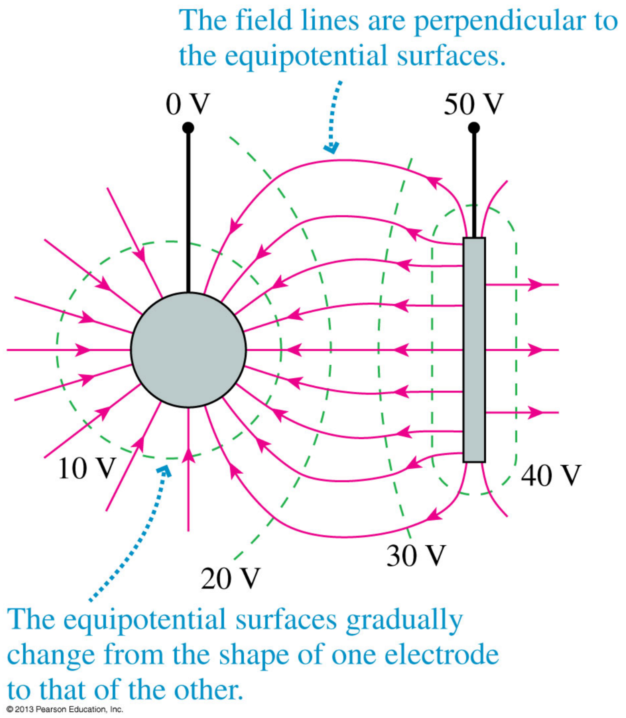
29.4:
A Conductor in Electrostatic Equilibrium

- *E*-field is ZERO inside a conductor in electrostatic equilibrium.
- Any two points within the conductor are at the *same* electric potential.
  - Entire conductor is at the *same* electric potential.
- The *exterior E*-field of a charged conductor is *perpendicular* to the surface.
- The *exterior E*-field (& surface charge density) is *largest* at sharp points.



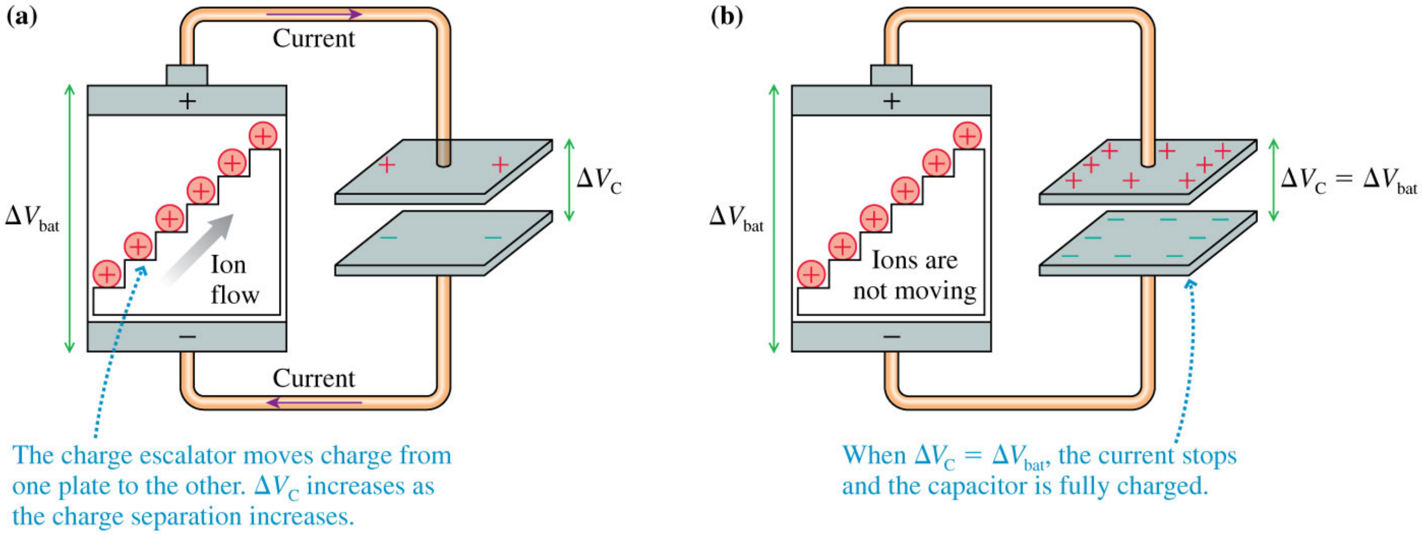
29.4: A Conductor in Electrostatic Equilibrium

- Close to the surface, the *E*-field is still *nearly perpendicular* to the surface.
  - Equipotential surface close to an electrode must *roughly match* the shape of the electrode.



29.5:
Capacitance and Capacitors

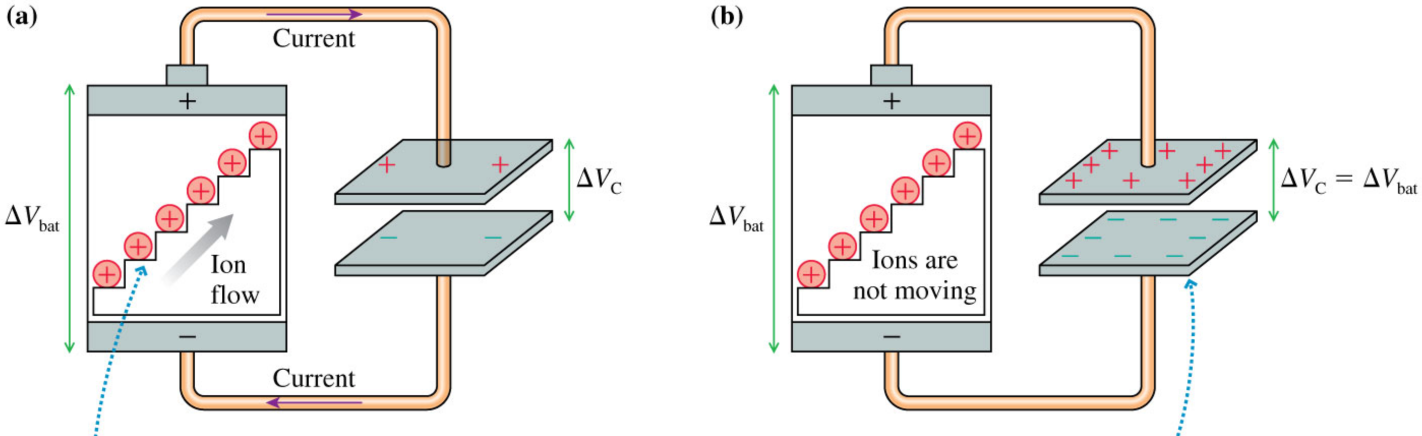
- How does a capacitor get charged?
  - Capacitor plates are connected to the two terminals of a battery via conducting wires.
- Once connected, what happens?
- How does ΔV_C compare to ΔV_{bat}?



29.5: Capacitance and Capacitors

- Any two points in a conductor in electrostatic equilibrium are at the *same potential*.

$$\Delta V_C = \Delta V_{bat}$$



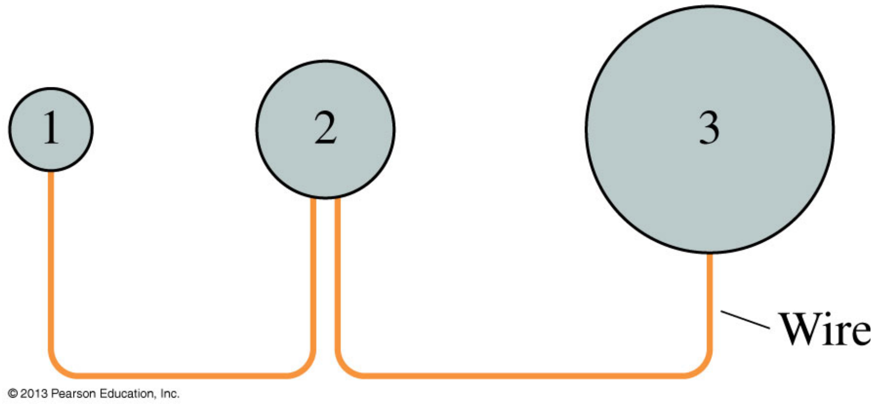
The charge escalator moves charge from one plate to the other. ΔV_C increases as the charge separation increases.

When $\Delta V_C = \Delta V_{bat}$, the current stops and the capacitor is fully charged.

Quiz Question 2

Three charged metal spheres of different radii are connected by a thin metal wire. The potential and electric field at the surface of each sphere are V and E.

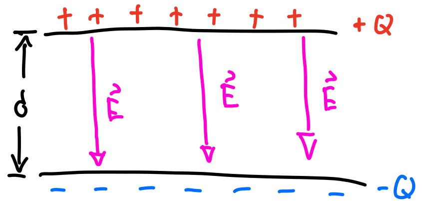
Which of the following is true?



1. $V_1 = V_2 = V_3$ and $E_1 < E_2 < E_3$
2. $V_1 > V_2 > V_3$ and $E_1 = E_2 = E_3$
3. $V_1 < V_2 < V_3$ and $E_1 = E_2 = E_3$
4. $V_1 = V_2 = V_3$ and $E_1 > E_2 > E_3$
5. $V_1 > V_2 > V_3$ and $E_1 > E_2 > E_3$
6. $V_1 < V_2 < V_3$ and $E_1 < E_2 < E_3$

Capacitance and Capacitors

How is the *charge* on capacitor plates, *Q*, related to the *potential difference* between the plates, ΔV_C?



$$E = \frac{\eta}{\epsilon_0} = \frac{Q}{A\epsilon_0}$$

$$V = ES$$

$$E = \frac{\Delta V}{S}$$

$$\frac{Q}{A\epsilon_0} = \frac{\Delta V}{S}$$

$$Q = \frac{A \Delta V \epsilon_0}{d}$$

$$\Delta V_{cap} \propto Q$$

Capacitance and Capacitors

How is the *charge* on capacitor plates, Q, related to the *potential difference* between the plates, ΔV_C?

$$\boxed{C \equiv \frac{Q}{\Delta V_C}}$$

- Capacitance

$$C = \frac{\epsilon_0 A}{d} \quad \text{(parallel-plate capacitor)}$$

- Notice: Capacitance is a *purely* geometric property of the electrodes
- SI Units: $[C] = \mathrm{C/V} \equiv \mathrm{F}$

  farad

i.e. 29.6: Charging a capacitor

The spacing between the plates of a 1.0 μF capacitor is 0.050 mm.

a. What is the surface area of the plates?

b. How much charge is on the plates if this capacitor is attached to a 1.5 V battery?

$C = 1.0 \times 10^{-6}\,F$

$S = 5.0 \times 10^{-5}\,m$

$\epsilon_0 = 8.85 \times 10^{-12} \frac{C^2}{Nm^2}$

$C = \frac{\epsilon_0 A}{d}$

$\frac{dC}{\epsilon_0} = A$

$\boxed{A = 5.6\,m^2}$

$\frac{\frac{C}{V}m}{\frac{C^2}{Nm^2}}$

$\frac{\cancel{C}}{V} m \cdot \frac{Nm^2}{C^{\cancel{2}}}$

$\frac{Nm^3}{J} = m^2$

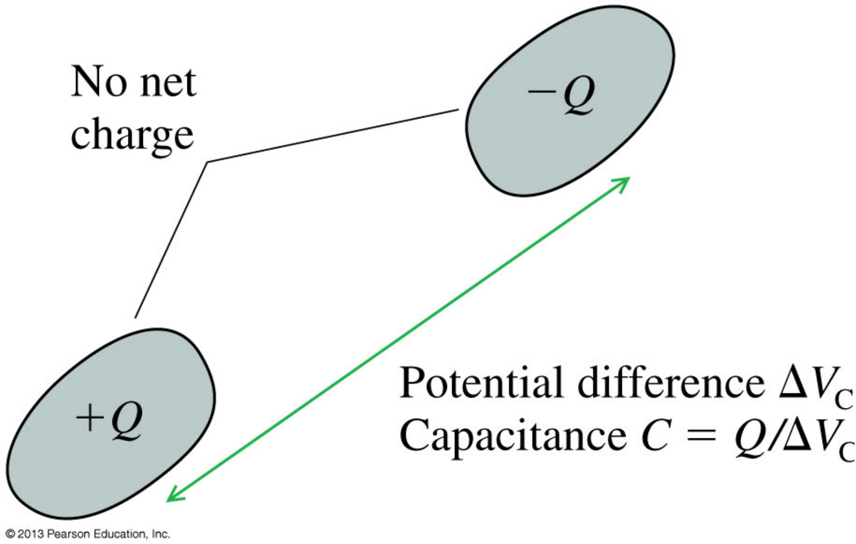
$Q = C\Delta V$

$Q = 1.5 \times 10^{-6} C$

Forming a Capacitor…

- Any two electrodes, regardless of their shape, form a capacitor.
- The capacitance of two electrodes is..

$$\boxed{C = \frac{Q}{\Delta V_C}}$$



- and depends *only* on the geometry of the electrodes.